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Role of Government in Promotion of Solar Energy Generation: An Analysis with Perspective of Beneficiaries

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Abstract

The Government of India realized the need of alternative energy sources. The early approach in implementation of alternative energy sources was solar energy focused on rural applications like, solar cookers and lanterns. Today, the promotional eco system for solar energy in India is highly structured and shift toward manufacturing promoters. The Government of India setup several promotional agencies like, MNRE and SECI evolved to promoting renewable energy prominently solar energy generation. These became the implementing agencies for the Production Linked Incentive (PLI) scheme for highly-efficiency solar PV modules. The present paper is focusing on role of Government in promotion of solar energy generation for domestic purpose with rationale of minimizing the cost of electricity bills of beneficiaries.

Keywords: Role of Government-Solar Energy-Scheme Incentives-Beneficiaries.

Introduction

Solar energy refers to the energy generated through the light and radiant heat emitted by the sun. Solar technologies are employed to capture this radiation for the purpose of energy production. The transition to green energy is rendered possible through dedicated community involvement. Solar energy is emerging as a major source for augmenting the share of renewable energy within India's total energy mix. Utility-scale, mass-level adoption of solar energy is of paramount importance in this energy transition. A government solar scheme constitutes an official policy, financial program, or subsidy instituted by the government to render solar energy affordable and accessible to the community. In this regard, the government engages power users through production incentives, tariffs, tax rebates, reliefs, and consumer subsidy incentives, thereby encouraging the adoption of solar energy. Through the nation's benchmark solar scheme PM-SURYA Ghar Muft Bijli Yojana, power users derive benefits in the form of a reduction in the upfront cost of solar system installation, as well as a reduction or elimination of electricity bill amounts through solar energy generation on their rooftops.

Review of Literature

The sun's direct radiative energy constitutes the singular and irreducible progenitor of solar power generation (Daniels, F. 1964). As a clean, renewable, and abundantly available energy resource, solar power has attained widespread applicability, extending from domestic-scale utilities to expansive industrial power installations. Around 90% overall reduction in module manufacturing prices over the past two decades (Lesourd, J.B. 2001). India's geographical positioning and prevailing meteorological conditions are eminently conducive to the harnessing of solar radiation; consequently, solar photovoltaic technology emerges as a particularly propitious and viable technological recourse for addressing the nation's twin imperatives of energy security and environmental sustainability (Nayak, *et al*., 2010),(Singh, *et al*., 2016) The transition from conventional fossil-fuel-dependent energy sources to renewable alternatives is of paramount and unequivocal significance (Sharma *et al*., 2012). India is to fulfil its energy security and environmental sustainability objectives by the year 2050. In pursuit of these overarching targets, the Government of India has undertaken concerted policy formulation and promotional initiatives (Barpatragohain. J. *et al*., 2015) (Jain, *et al* 2020). Salient among these measures is: the establishment of a unified national grid infrastructure to facilitate seamless integration of renewable energy; the standardisation of regulatory guidelines governing the generation, transmission, and distribution of renewable energy to end-consumers (Yenneti, K. 2016) and the articulation of a comprehensive clean energy policy framework encompassing tariff structures, capital subsidies, taxation reliefs, and scheme-based incentives, all calibrated to

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augment the proportional contribution of solar and other renewable sources within the nation's aggregate energy portfolio (Abdmouleh., *et al*., 2015, Bansal, N., 2021, Dubey, B., *et al*., 2023).
The proliferation and sustained generation of solar energy remain substantially contingent upon active community participation and stakeholder engagement (Colasante, 2022). Correspondingly, the promotion of eco-conscious, energy-efficient architectural design, together with sustainable agricultural and industrial practices, constitutes a paramount and abiding priority for the government (Abdalla, A.N., *et al*., 2023). Replacing obsolescent and inefficient modules with technologically advanced solar photovoltaic panels and net metering facilities; extending consumer-accessible, low-interest financing instruments; and instituting differential and innovative tariff structures—such as block rates and time-of-use rates—constitute pivotal interventions. Augmented financial incentives are indispensable to the integration of greater solar energy capacity into the grid from producers and to the successful implementation of renewable energy projects (Gamonwet *et al*., 2023)
Energy audits corroborate that solar rooftop photovoltaic systems adequately satisfy energy demand and substantially attenuate carbon emissions at the utility level, thereby fostering the development of energy-efficient residential infrastructure (Darshan, A, *et al*., 2022). Property developers and farmers, through the installation of solar systems, secure long-term reductions in electricity expenditure while simultaneously contributing to environmental conservation (Trommsdorff, M. *et al*., 2023). Although the prospect of long-run electricity bill savings constitutes the principal motivating factor for residents operating under the net metering facility, the accrual of revenue through the sale of surplus solar energy under the gross metering facility likewise serves as a contributory incentive (Mota, B., *et al* 2024) (Yuvaraj., *et al* 2025). The installation of a solar rooftop photovoltaic system, facilitated through solar incentive schemes, substantially diminishes the initial capital outlay, reduces or altogether eliminates electricity expenditure over the system's operational lifespan, and enables the accrual of modest revenue through the sale of surplus energy to DISCOMs (Sinha, R. 2025). Nevertheless, solar energy curtailment, occasioned by heightened utilisation of energy-intensive appliances, may exert an adverse effect upon solar revenue generation (Shimada, H., *et al*., 2023) (Gupta, D., *et al*., 2025) ((Tiwari, A., *et al* 2025). Government-led initiatives and technical assistance programmes facilitate the adoption of solar energy within local communities by simplifying and streamlining permitting and inspection procedures, mitigating soft costs, establishing eco-conscious construction codes, and imparting training to government representatives. Such measures are indispensable to the promotion and proliferation of solar energy.

Research Objective

The following objective of the study based on focused topic of the paper

- Role of Government Schemes for solar energy generation and its impact on electricity bill saving of beneficiaries.

Hypothesis

Based on the objective of the study the following hypothesis is framed;
There is positive relationship between Government Schemes of solar energy generation and electricity bill savings of beneficiaries of Government schemes.

Research Methodology

The present research paper is based on primary data and analytical in nature. The primary data were collected from target beneficiaries of Government schemes of solar energy generation. The Factor analysis technique was used for analysis and interpretation of primary data as follows.

Analysis and Interpretation

To analyse the role of government schemes in promoting solar energy generation and its impact on electricity bills savings. 13 variables/factors are considered for analysis. The KMO and Bartlett’s Test with VARIMAX Rotated Component analysis is adopted to test factor which are impact on beneficiaries for installation of solar energy generation system through Government Schemes.

Table 1: KMO and Bartlett’s Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		**0.586**
Bartlett's Test of Sphericity	Approx. Chi-Square	101.004
	df	88
	Sig.	0.021*

$^*p<0.05$

KMO and Bartlett's Test

The suitability of the data for factor analysis was first examined using the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's Test of Sphericity. The KMO value was 0.586, which is above the minimum acceptable threshold of 0.50 suggested by Kaiser (1974). This indicates that the sample is adequately suitable for factor analysis, although the sampling adequacy may be considered moderate. Further, Bartlett's Test of Sphericity was statistically significant (χ^2 = 101.004, df = 88, p = 0.021), rejecting the null hypothesis that the correlation matrix is an identity matrix. The significant result confirms that sufficient correlations exist among the variables to justify the application of factor analysis. Therefore, both the KMO statistic and Bartlett's test indicate that the data are appropriate for Principal Component Analysis (PCA).

Table 2: VARIMAX – Rotated Component Analysis-Electricity Bill Saving.

Sl. No.	**Factors**	**Rotated Component Factors**						**Communalities**
		1	**2**	**3**	**4**	**5**	**6**	
1	Electricity bill constitutes an important recurring expense in family budget	.006	.192	-.029	-.763	.106	-.021	.631
2	Power tariff hikes negatively impact users' power bill savings.	.082	.522	.240	.427	.050	-.103	.532
3	Scheme benefit in decreasing or eliminating dependency on Grid/ESCOM power supply	-.022	.742	.005	-.051	.142	-.130	.590
4	Scheme benefit in lowering electricity bill amount	-.647	-.054	.005	.020	.013	-.130	.439

5	Net metering facility for power import or export calculation	-.153	.028	.644	.236	.052	-.139	.516
6	Scheme supports generation of sufficient electricity through solar rooftop system for self-consumption	.024	.596	-.014	-.221	-.212	.175	.480
7	Schemes help in create electricity surplus generation through solar plant	.056	.007	.036	-.182	.797	.117	.687
8	Scheme benefit in reducing or elimination of electricity bill amount	.034	-.048	.027	.029	.090	.932	.881
9	DISCOMs/ESCOM in reducing in electricity bill amount	-.113	.252	-.458	.416	-.276	.183	.569
10	Possibility of free electricity supply through solar system for home power needs	.631	-.010	-.039	-.280	-.178	-.099	.520
11	Saving bill amount to other household expenses	-.153	.037	-.489	.155	.557	-.056	.601
12	Solar schemes promote to electricity bills savings	.002	.096	.586	-.043	-.102	.148	.387
13	Power bill savings through solar system promotes other potential buyers	.678	-.036	-.020	.277	.193	-.047	.578
	Eigen Values	1.349	1.295	1.270	1.260	1.192	1.047	7.413
	Percentage of Trace	10.375	9.964	9.767	9.691	9.166	8.056	57.019

***(Source:** Primery Data)*

***Note:** Extraction Method: Principal Component Analysis, Rotation Method: Varimax with Kaiser Normalization*

Principal Component Analysis (Varimax Rotation)

Principal Component Analysis with Varimax rotation extracted six factors having eigenvalues Greater than one. Together, these six factors explained 57.02 per cent of the total variance in respondents' perceptions regarding electricity bill savings under the solar rooftop scheme. In behavioural and social science research, a cumulative variance exceeding 50 per cent is generally considered satisfactory, indicating that the extracted factors adequately represent the underlying construct. The communalities ranged from 0.387 to 0.881, indicating that most variables were reasonably well represented by the extracted factors. Particularly, the statement "Scheme benefits in reducing or elimination of electricity bill amount" exhibited the highest communality (0.881), suggesting that this variable was very well explained by the extracted factors.

Interpretation of Individual Factors

Factor 1: Economic Benefits of Electricity Bill Saving.

Statement	Loading
Power bill savings through solar system promotes other potential buyers	0.678
Possibility of free electricity supply through solar system for home power needs	0.631
Scheme benefit in lowering electricity bill amount	-0.647

This factor consists of three statements with high factor loadings.

These variables indicate that respondents primarily associate the solar rooftop scheme with reducing electricity expenses and encouraging wider adoption through economic benefits. Although one loading is negative, its absolute magnitude is high (>0.60), indicating strong association with this factor. Hence, Factor 1 may be named "Economic Benefits of Electricity Bill Saving."

Factor 2: Reduction in Grid Dependency.

Statement	Loading
Scheme benefits in decreasing dependency on Grid/ESCOM power	0.742
Scheme support sufficient electricity generation for self-consumption	0.596
Power tariff hikes negatively impact users' power bill savings	0.522

This factor consists of three statements with high factor loadings.

These variables describe respondents' perception that solar rooftop systems reduce dependence on conventional electricity supply while protecting households from increasing electricity tariffs. Therefore, Factor 2 can be termed "Reduction in Grid Dependency and Tariff Protection."

Factor 3: Net Metering and Financial Efficiency.

Statement	Loading
Net metering facility	0.644
Solar schemes promote electricity bill savings	0.586

This factor consists of two statements with high factor loadings.

The factor highlights respondents' awareness of the role of net metering in improving electricity bill savings through efficient utilization of generated electricity. Accordingly, Factor 3 may be labelled "Net Metering and Financial Efficiency."

Factor 4: Household Electricity Expenditure.

Statement	Loading
Electricity bill constitutes an important recurring family expense	-0.763

This factor consists of a statement with high factor loading.

This factor reflects respondents' concern regarding electricity expenditure as a regular household financial burden. Hence, Factor 4 may be named "Household electricity Expenditure".

Factor 5: Surplus Electricity Generation.

Statement	Loadings
Scheme helps create electricity surplus generation	0.797
Saving bill amount to other household expenses	0.557

This factor consists of two statements with high factor loadings.

The factor indicates that respondents perceive surplus electricity generation as a means of reducing household expenditure and improving financial savings. Therefore, Factor 5 may be labelled "Surplus Energy Generation and Household Savings".

Factor 6: Maximum Bill Reduction

Statement	Loading
Scheme benefit in reducing or eliminating electricity bill amount	0.932

Only one statement loads strongly on this factor.
The exceptionally high loading indicates that respondents overwhelmingly perceive complete or substantial elimination of electricity bills as principal benefit of the solar rooftop scheme. Thus, Factor 6 can be termed "Maximum Electricity Bill Reduction".

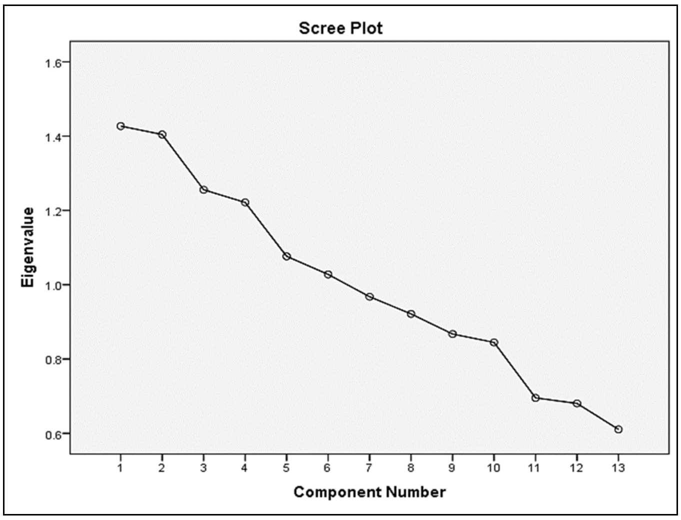

Fig 1: Electricity Bill Saving.

Interpretation of Scree Plot

The scree plot illustrates the eigenvalues associated with each principal component.

- The eigenvalues decline sharply for the initial components and gradually level off after the sixth component.
- According to Kaiser's criterion (Eigenvalue > 1), six components were retained.
- The scree plot also supports the retention of these six factors, as the curve begins to flatten after the sixth component, indicating that the remaining components contribute relatively little additional explanatory power.
- Therefore, the six-factor solution adequately captures the underlying dimensions of respondents' perceptions regarding electricity bill savings.

Outcome of Analysis

The exploratory factor analysis confirmed that respondents' perceptions regarding electricity bill savings under the solar rooftop scheme are multidimensional. Six latent factors were extracted, collectively explaining 57.02% of the total variance. These factors primarily represent:

i). Economic benefits of electricity bill saving.
ii). Reduction in grid dependency and tariff protection.
iii). Net metering and financial efficiency.
iv). Household electricity expenditure.
v). Surplus energy generation and household savings.
vi). Maximum electricity bill reduction.

The acceptable KMO value (0.586), significant Bartlett's test ($p < 0.05$), satisfactory communalities, and cumulative explained variance support the adequacy and validity of the extracted factor structure. Overall, the results suggest that respondents perceive the solar rooftop scheme as an effective mechanism for reducing household electricity expenditure, enhancing energy self-sufficiency, and improving long-term financial savings.

Conclusion

The exploratory factor analysis indicated and confirm that the perception of beneficiaries towards government schemes for solar energy generation, regarding electricity bill savings 13 Factors under six Rotated Compound Factors (RCF) are extracted. The communalities collectively explaining 57.019percent out of which RCF1 carries 10.375 percent, RCF 2 carries 9.964 percent, RCF 3 carries 9.767 percent, RCF 4 carries 9.691 percent, RCF 5 carries 9.166 percent, and RCF 6 carries 8.056 percent. It is concluded that, electricity bill constitutes an important recurring expense in family budget, Scheme benefit in reducing or elimination of electricity bill amount, Scheme help in create electricity surplus generation through solar plant are highly impact on Electricity Bill Savings.

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